



US011931310B2

(12) **United States Patent**
Roh et al.

(10) **Patent No.:** **US 11,931,310 B2**
(45) **Date of Patent:** **Mar. 19, 2024**

(54) **DRIVING MODULE AND MOTION ASSISTANCE APPARATUS INCLUDING THE SAME**

(52) **U.S. Cl.**
CPC *A61H 3/00* (2013.01); *A61F 2/68* (2013.01); *A61F 2/70* (2013.01); *A61H 1/0237* (2013.01);

(Continued)

(71) Applicant: **Samsung Electronics Co., Ltd.**,
Suwon-si (KR)

(58) **Field of Classification Search**

CPC *A61H 3/00*; *A61H 1/02*; *A61H 2201/16*; *A61H 2201/14*; *A61H 2003/007*;
(Continued)

(72) Inventors: **Se-Gon Roh**, Suwon-si (KR);
Jeonghun Kim, Hwaseong-si (KR);
Minhyung Lee, Anyang-si (KR); **Youn Baek Lee**, Yongin-si (KR); **Jongwon Lee**, Uiwang-si (KR); **Byungjune Choi**, Gunpo-si (KR); **Hyun Do Choi**, Yongin-si (KR)

(56) **References Cited**

U.S. PATENT DOCUMENTS

30,271 A * 10/1860 Vergnes H01F 27/323
336/186
135,312 A * 1/1873 Bevelander B65G 47/24
221/172

(Continued)

(73) Assignee: **Samsung Electronics Co., Ltd.**,
Suwon-si (KR)

FOREIGN PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

JP 2006-075226 A 3/2006
JP 2006-320351 A 11/2006

(Continued)

(21) Appl. No.: **18/074,677**

(22) Filed: **Dec. 5, 2022**

OTHER PUBLICATIONS

(65) **Prior Publication Data**

US 2023/0094084 A1 Mar. 30, 2023

U.S. Appl. No. 17/180,281, filed Feb. 19, 2021; Roh et al.

(Continued)

Related U.S. Application Data

(60) Continuation of application No. 17/180,281, filed on Feb. 19, 2021, now Pat. No. 11,534,360, which is a
(Continued)

Primary Examiner — Garrett K Atkinson

(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye P.C.

(30) **Foreign Application Priority Data**

Jan. 7, 2015 (KR) 10-2015-0002072

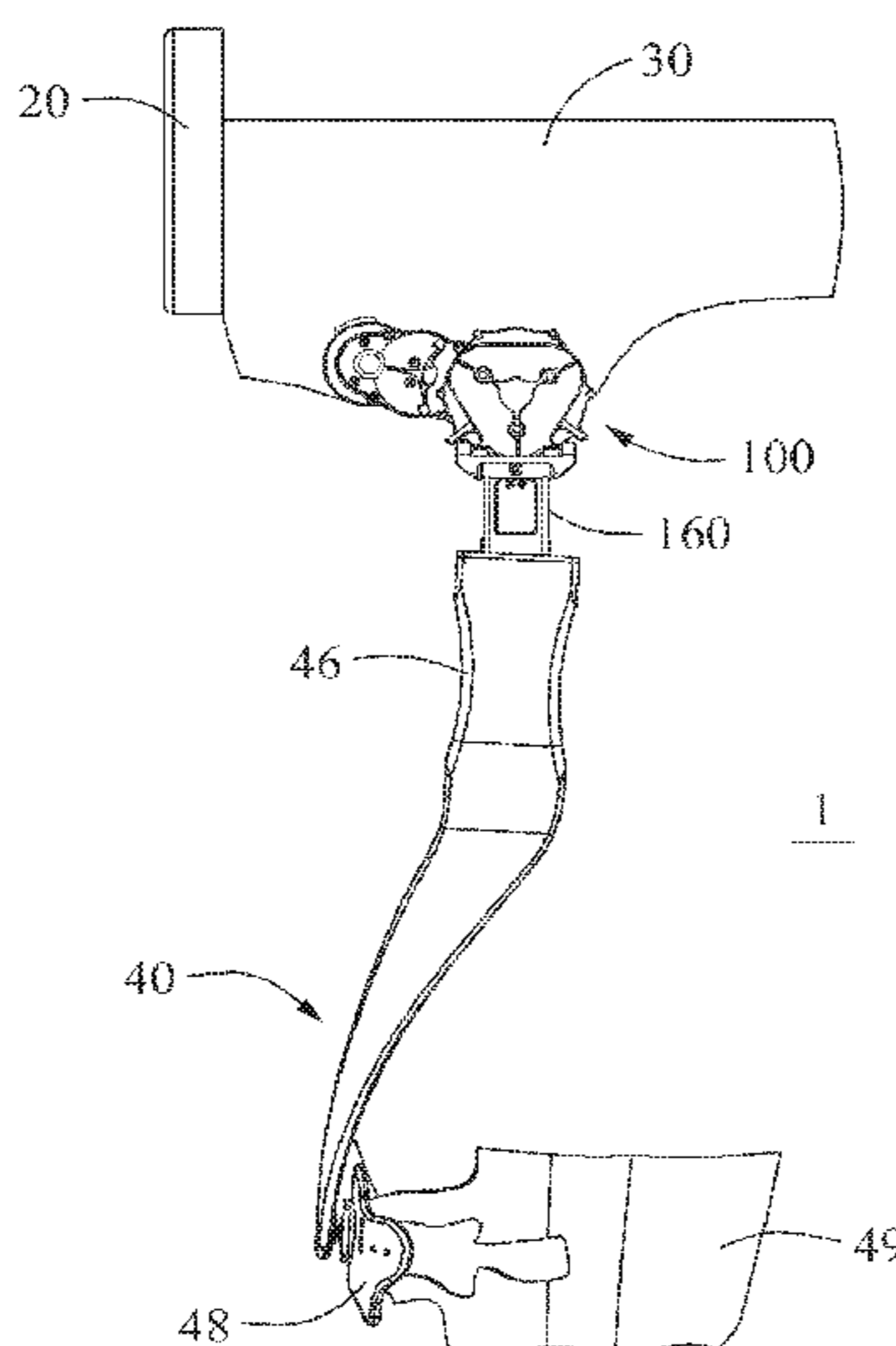
(57) **ABSTRACT**

A driving module including a driving source configured to generate power, a gear train including a decelerating gear set configured to receive driving power from the driving source and a ring gear attached to one side thereof, and a rotary joint including at least one planetary gear configured to rotate using power received from an output end of the decelerating gear set and to revolve along the ring gear is disclosed.

(51) **Int. Cl.**
A61H 3/00 (2006.01)
A61F 2/68 (2006.01)

(Continued)

4 Claims, 13 Drawing Sheets



Related U.S. Application Data

continuation of application No. 16/410,247, filed on May 13, 2019, now Pat. No. 10,952,917, which is a division of application No. 16/263,531, filed on Jan. 31, 2019, now Pat. No. 10,952,915, which is a division of application No. 14/796,583, filed on Jul. 10, 2015, now Pat. No. 10,231,894.

(51) **Int. Cl.**

A61F 2/70 (2006.01)
A61H 1/02 (2006.01)
F16H 1/20 (2006.01)
F16H 1/28 (2006.01)
F16H 37/04 (2006.01)
F16H 57/02 (2012.01)

(52) **U.S. Cl.**

CPC *A61H 1/0244* (2013.01); *A61H 1/0274* (2013.01); *F16H 57/02* (2013.01); *A61H 2003/007* (2013.01); *A61H 2201/1215* (2013.01); *A61H 2201/1472* (2013.01); *A61H 2201/1628* (2013.01); *A61H 2201/164* (2013.01); *A61H 2201/165* (2013.01); *A61H 2201/1676* (2013.01); *A61H 2201/5007* (2013.01); *F16H 1/20* (2013.01); *F16H 1/28* (2013.01); *F16H 37/041* (2013.01)

(58) **Field of Classification Search**

CPC A61H 2201/50; A61H 2201/12; A61H 1/0237; A61H 1/0244; A61H 1/0274; A61H 2201/1472; A61H 2201/1628; A61H 2201/164; A61H 2201/1676; A61H 2201/1215; A61H 2201/165; A61H 2201/5007; A61H 2201/0157; A61H 1/0262; A61H 3/008; A61H 2201/1223; A61H 2201/1463; A61H 2205/10; F16H 57/02; F16H 1/28; F16H 1/02; F16H 37/04; F16H 1/20; F16H 37/041; A61F 2/68; A61F 2/70

See application file for complete search history.

(56)

References Cited

U.S. PATENT DOCUMENTS

174,690 A * 3/1876 Macy G02B 27/08 359/617
 198,116 A * 12/1877 Johnson A01C 7/18 111/43
 222,532 A * 12/1879 Raedler et al. C04B 28/02 264/333
 298,939 A * 5/1884 Briggs C05F 3/00 71/25
 4,715,243 A * 12/1987 Morishita F16H 55/06 74/DIG. 10
 5,067,479 A * 11/1991 Saringer A61H 1/0285 601/40
 5,161,036 A * 11/1992 Mannichi H04N 1/4051 358/448
 5,683,351 A * 11/1997 Kaiser A61H 1/0288 601/40
 6,198,182 B1 3/2001 Bustamante et al.
 7,377,875 B2 * 5/2008 Shiina F16H 35/008 475/331
 7,404,782 B2 * 7/2008 Kudoh A61H 3/008 475/903
 7,559,909 B2 * 7/2009 Katoh A61H 1/0255 602/26
 7,998,096 B1 * 8/2011 Skoog A61H 3/00 601/5

8,588,651 B2 * 11/2013 Matsuda F16H 1/46 399/167
 8,671,788 B2 * 3/2014 Lim F16H 57/043 74/89.11
 9,351,900 B2 * 5/2016 Walsh A63B 23/0355
 9,581,220 B2 * 2/2017 Kim H02K 7/116
 10,231,894 B2 3/2019 Roh et al.
 10,952,915 B2 3/2021 Roh et al.
 10,952,917 B2 3/2021 Roh et al.
 2002/0077708 A1 * 6/2002 Iversen A61F 2/585 623/64
 2003/0222532 A1 * 12/2003 Hsu F16H 57/033 310/68 R
 2005/0075953 A1 * 4/2005 Lee G06Q 40/04 705/28
 2006/0135312 A1 * 6/2006 Shiina F16H 35/008 475/339
 2007/0106190 A1 5/2007 Katoh et al.
 2008/0161937 A1 7/2008 Sankai
 2009/0299480 A1 * 12/2009 Gilbert A61F 5/0125 623/18.11
 2010/0198116 A1 * 8/2010 Hirata A61H 1/0244 601/34
 2011/0066093 A1 * 3/2011 Vess A61H 11/00 601/151
 2011/0293328 A1 * 12/2011 Matsuda G03G 21/1647 399/167
 2012/0174690 A1 * 7/2012 Lim F16H 19/04 74/29
 2014/0298939 A1 * 10/2014 Kim B25J 9/126 74/411.5
 2015/0196450 A1 * 7/2015 Lee A61H 1/0266 901/28
 2015/0321341 A1 * 11/2015 Smith A61H 3/00 623/57
 2016/0015589 A1 * 1/2016 Lee A61H 1/024 602/16
 2016/0030271 A1 * 2/2016 Roh A61H 1/0244 74/89.22
 2016/0193102 A1 * 7/2016 Roh F16H 57/02 475/343
 2016/0317375 A1 * 11/2016 Simon A61F 2/605

FOREIGN PATENT DOCUMENTS

JP 2009-095645 A 5/2009
 JP 2010-000204 A 1/2010
 JP 2011-131025 A 7/2011
 JP 2012-165822 A 9/2012
 JP 2013-000296 A 1/2013
 JP 5161036 B2 3/2013
 JP 2013-233406 11/2013
 KR 2005-0075953 A 7/2005
 KR 10-2012-0124677 11/2012
 KR 10-1417895 B1 7/2014

OTHER PUBLICATIONS

U.S. Appl. No. 16/410,247, filed May 13, 2019; Roh et al.
 U.S. Appl. No. 16/263,531, filed Jan. 31, 2019; Roh et al.
 U.S. Appl. No. 14/796,583, filed Jul. 10, 2015; Roh et al.
 Notice of Allowance dated Sep. 28, 2021, in Korean Application No. 10-2015-0002072.
 Non-Final Office Action dated Nov. 30, 2017, in corresponding U.S. Appl. No. 14/796,583.
 Final Office Action dated Apr. 5, 2018, in corresponding U.S. Appl. No. 14/796,583.
 Notice of Allowance dated on Nov. 1, 2018, in corresponding U.S. Appl. No. 14/796,583.
 Non-Final Office Action dated Apr. 6, 2020, in corresponding U.S. Appl. No. 16/263,531.
 Notice of Allowance dated Jul. 27, 2020, in corresponding U.S. Appl. No. 16/263,531.
 Final Office Action dated Aug. 6, 2020, in corresponding U.S. Appl. No. 16/410,247.

(56)

References Cited

OTHER PUBLICATIONS

Notice of Allowance dated Nov. 18, 2020, in corresponding U.S.
Appl. No. 16/410,247.

Notice of Allowance dated Nov. 20, 2020, in corresponding U.S.
Appl. No. 16/263,531.

* cited by examiner

FIG. 1

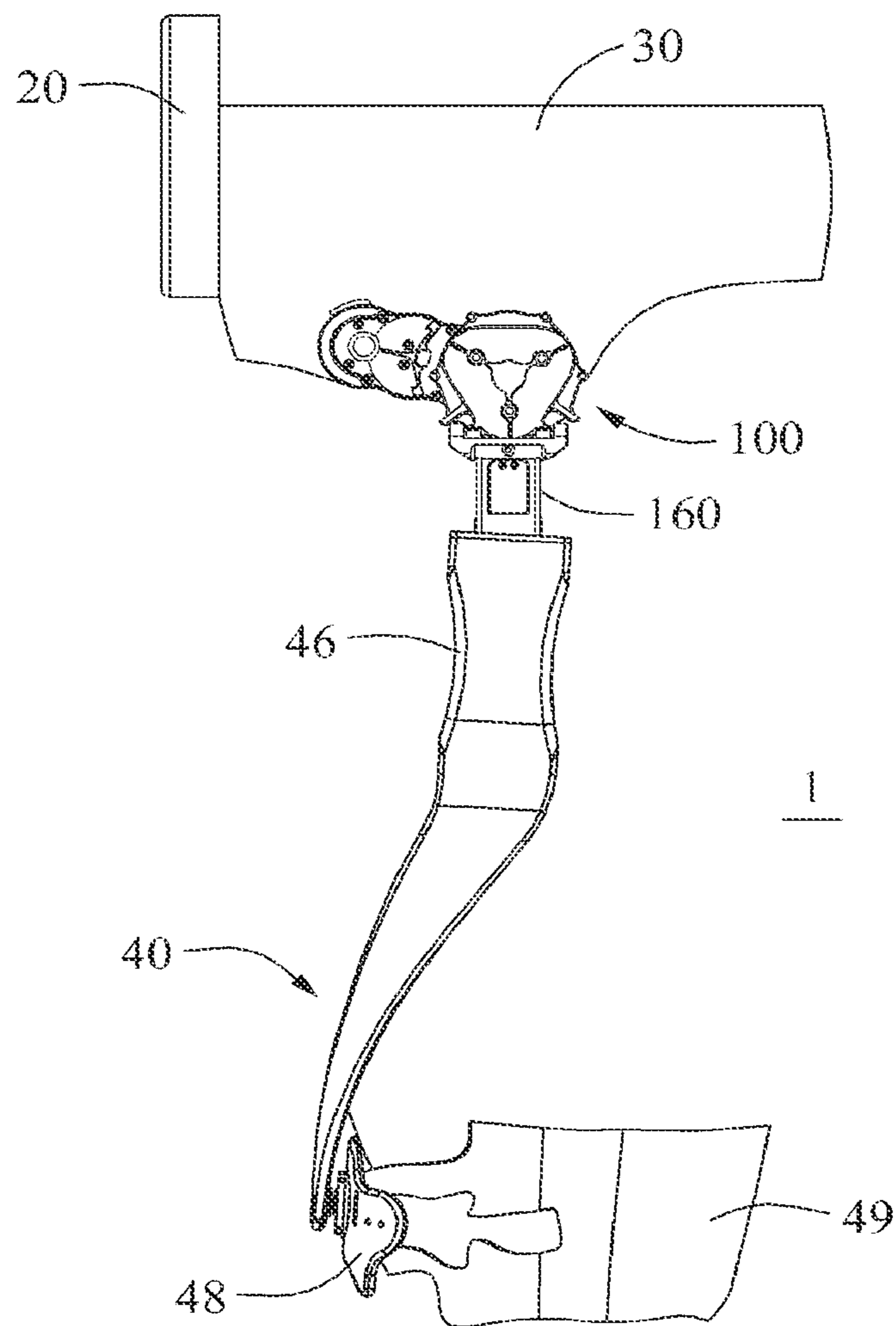


FIG. 2

100

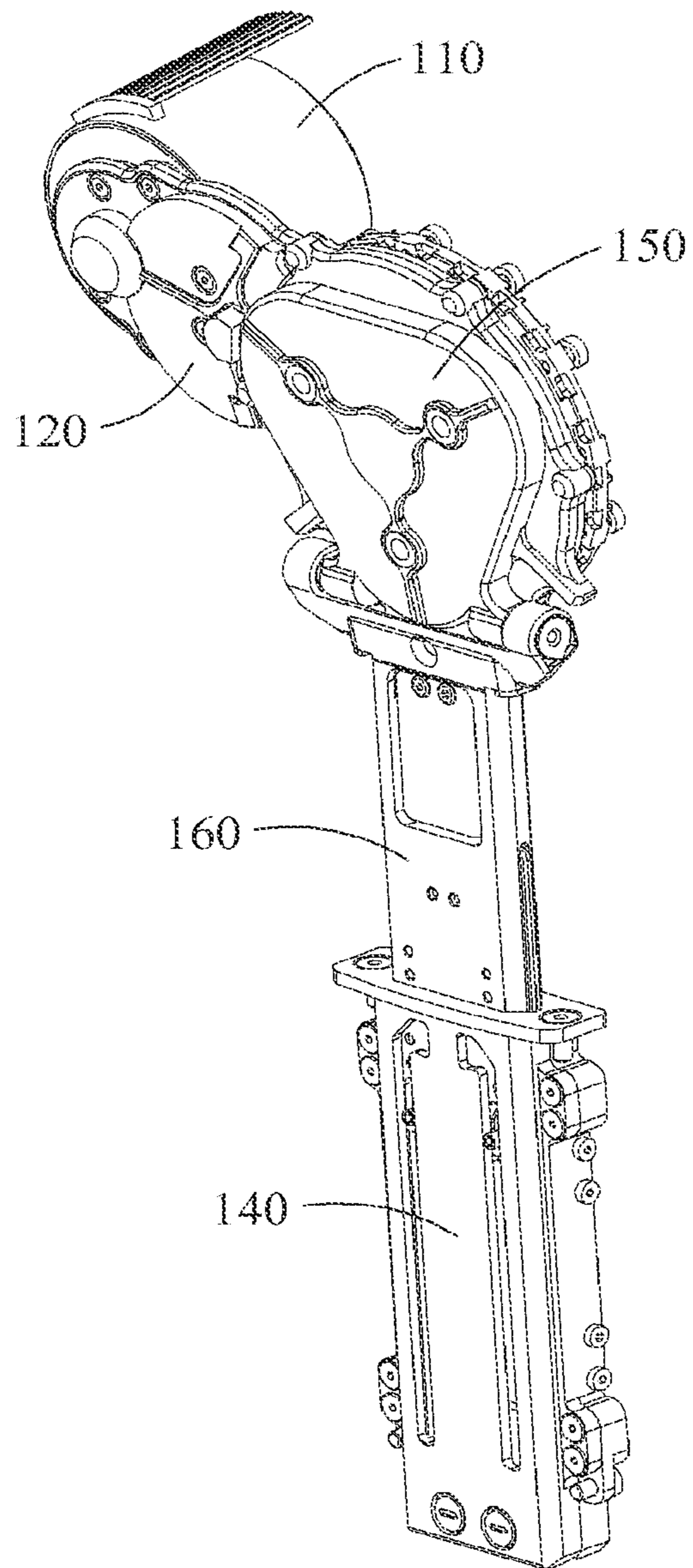


FIG. 3

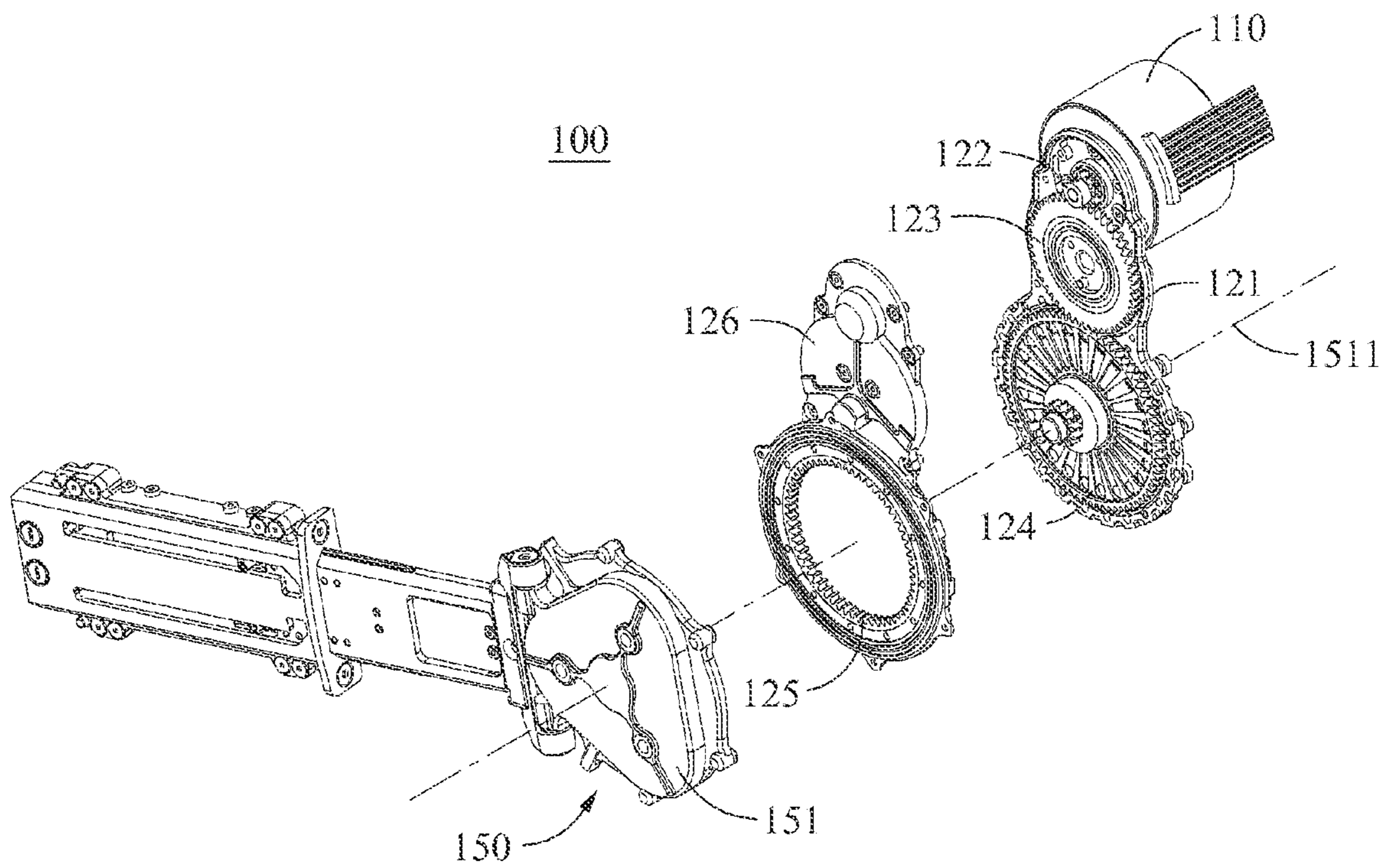


FIG. 4

100

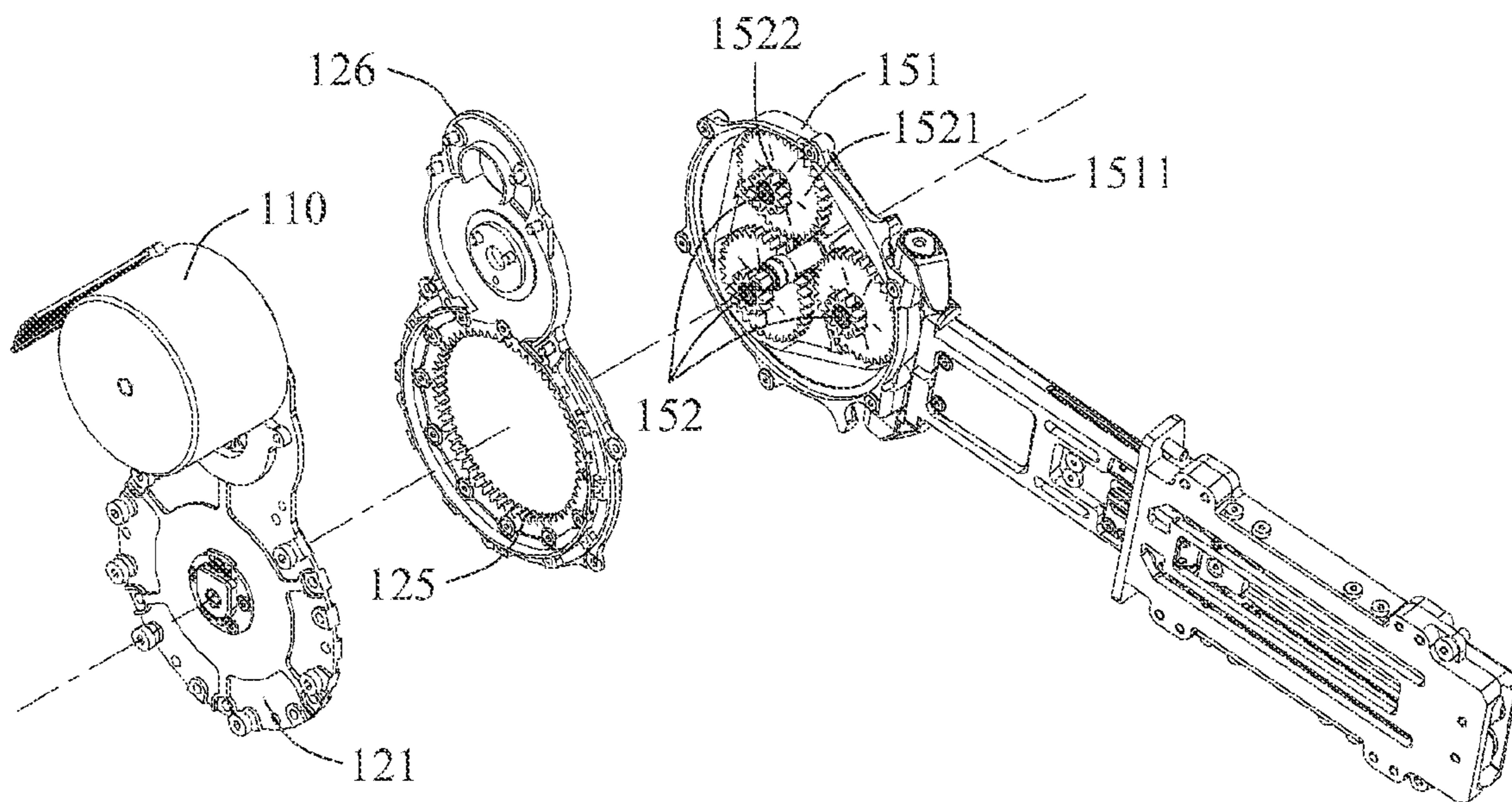


FIG. 5

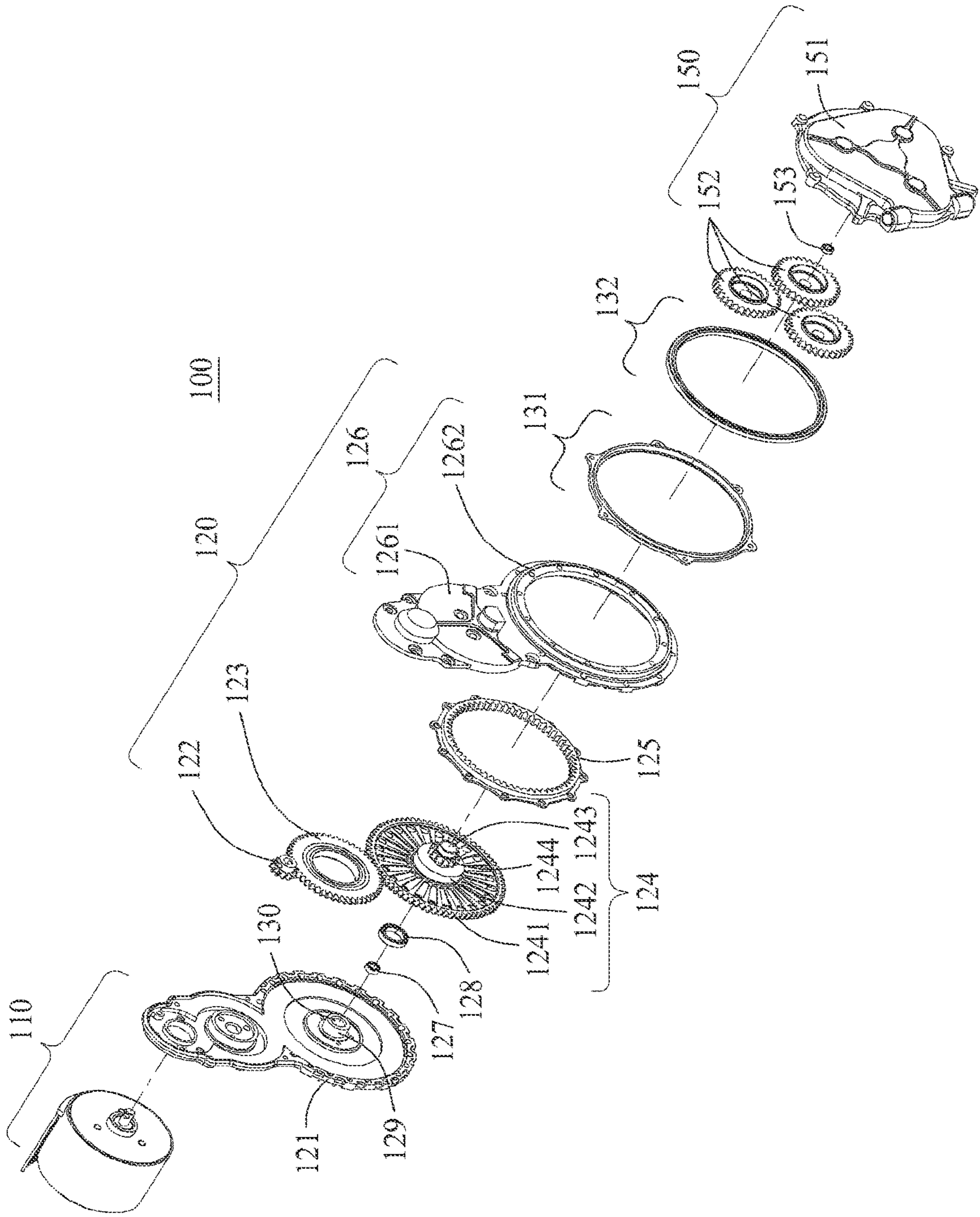


FIG. 6

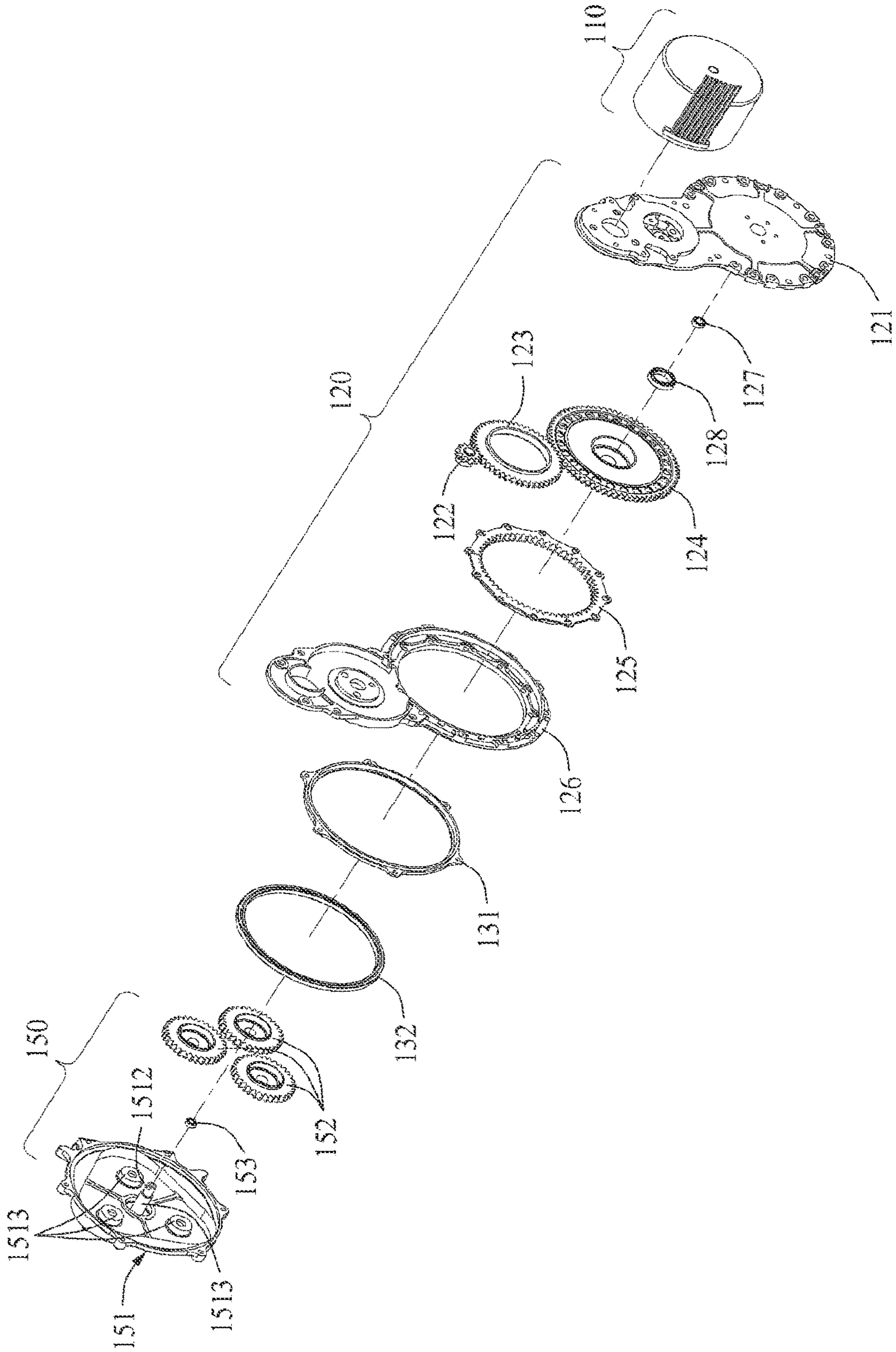


FIG. 7

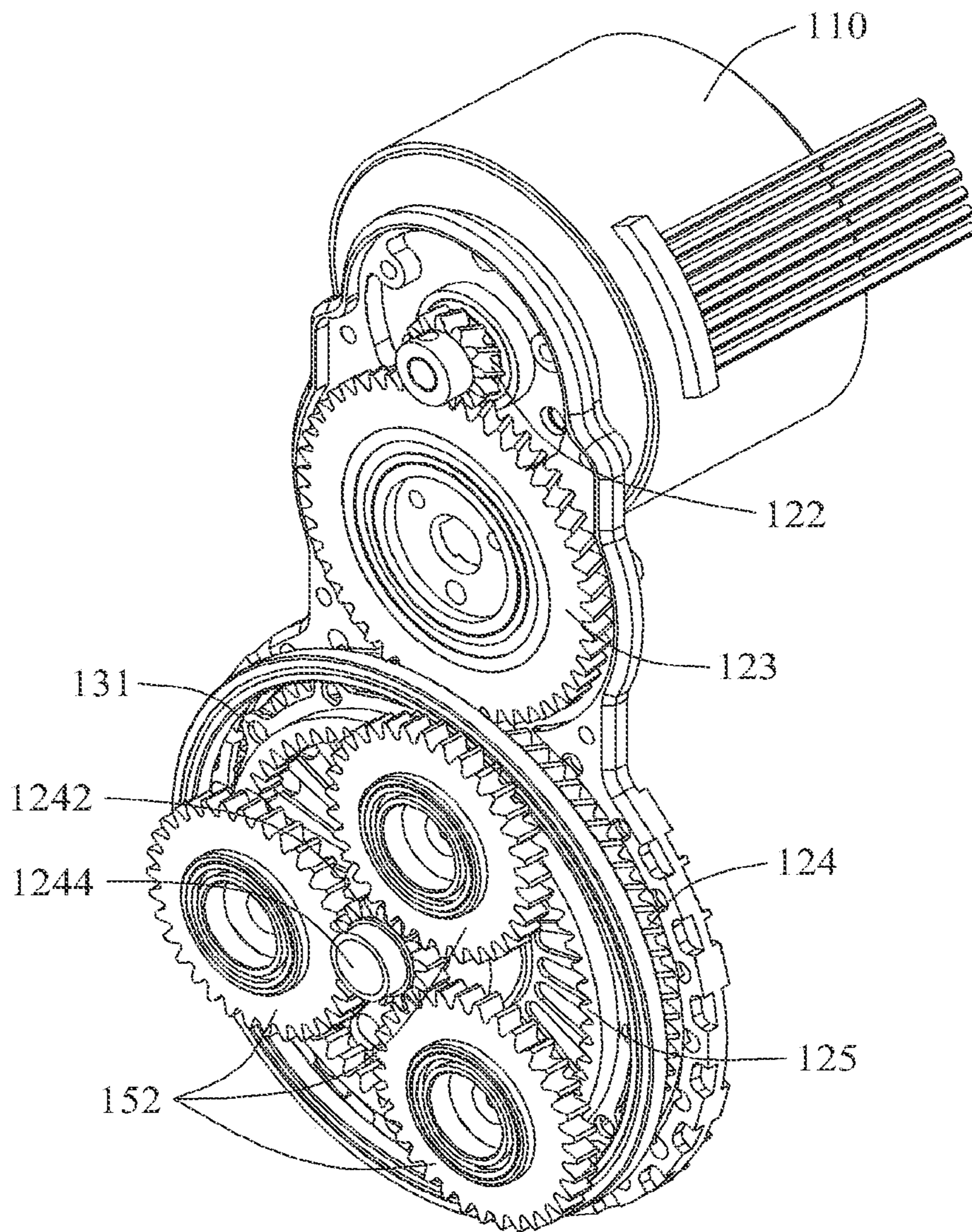


FIG. 8

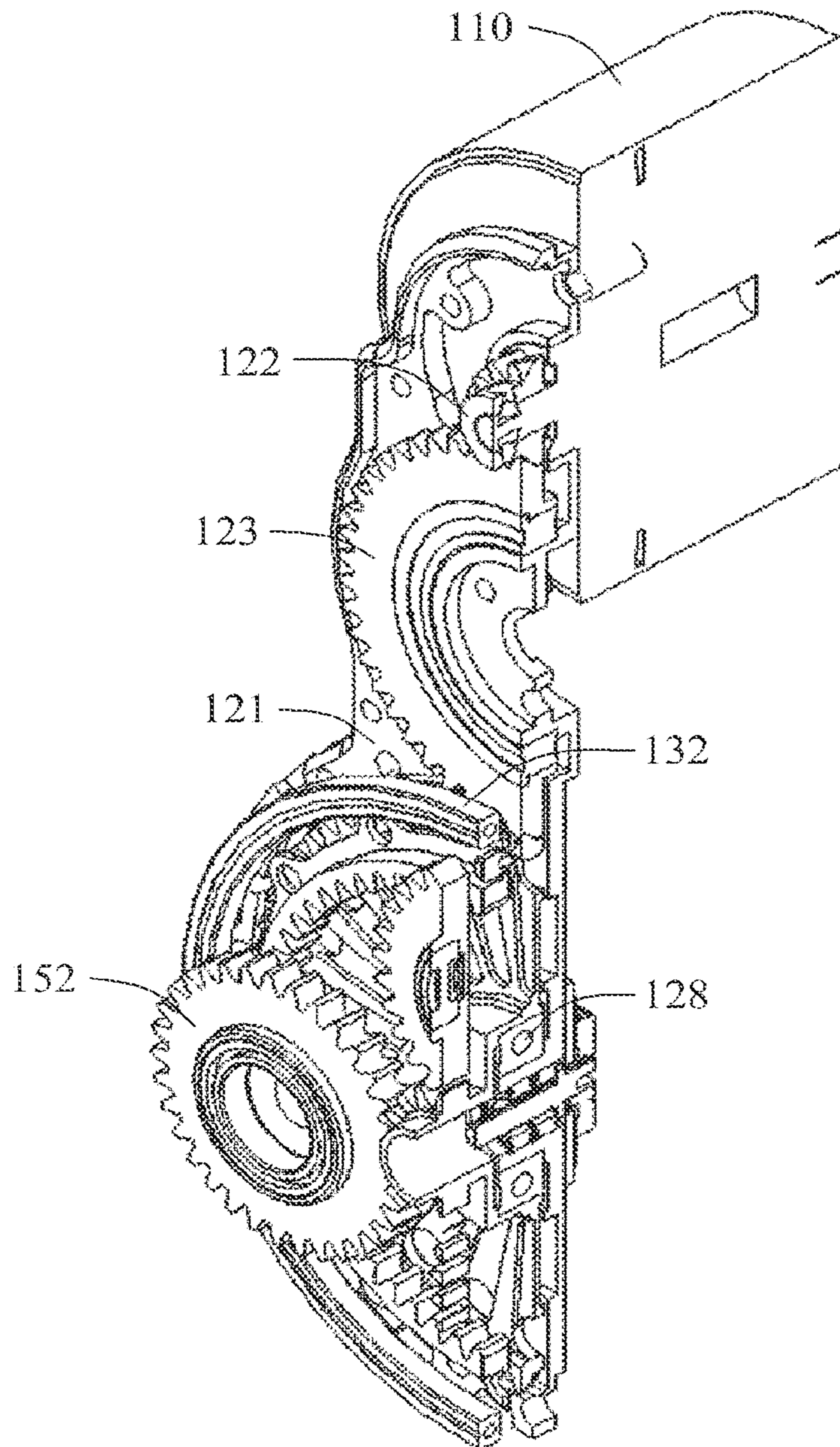


FIG. 9

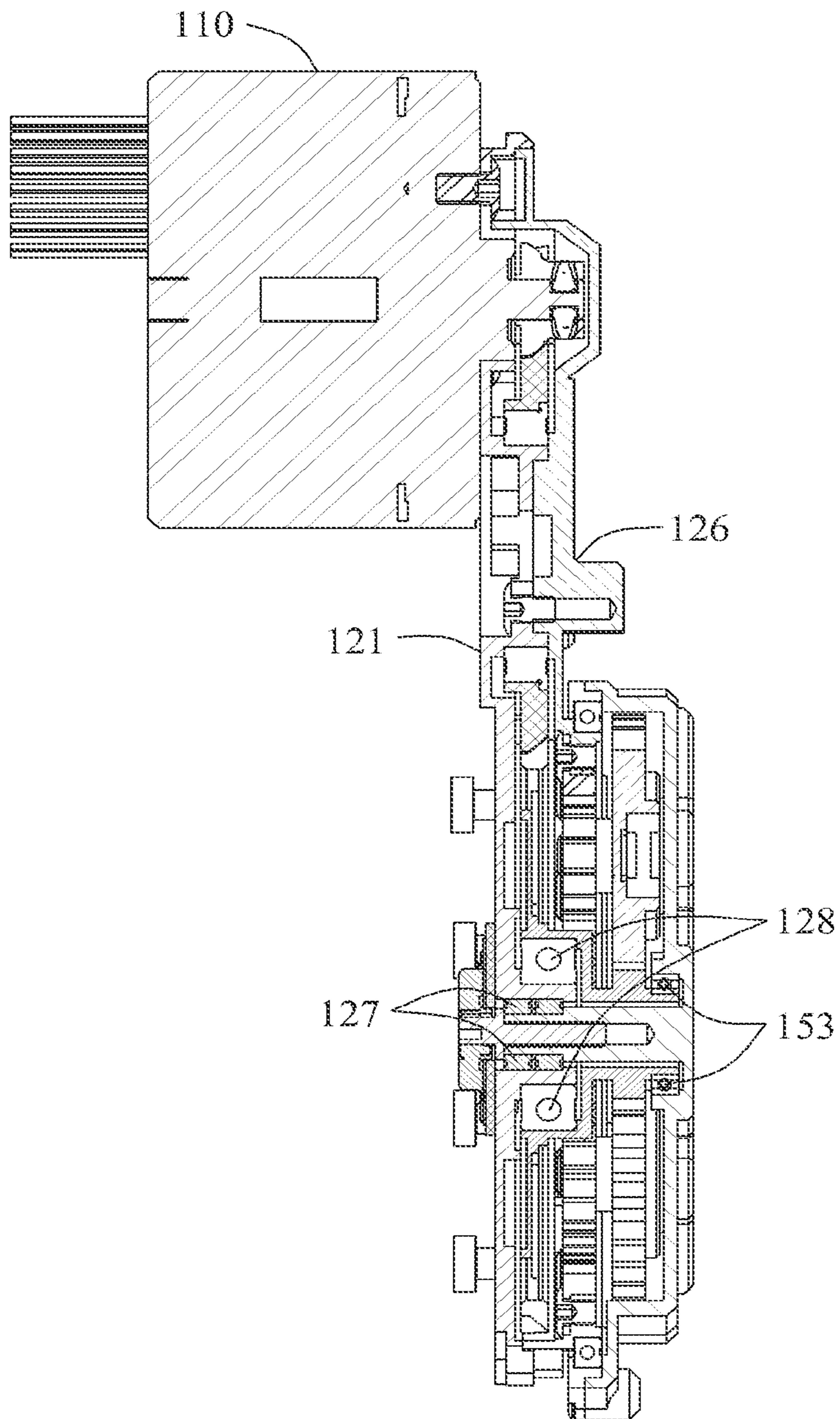


FIG. 10

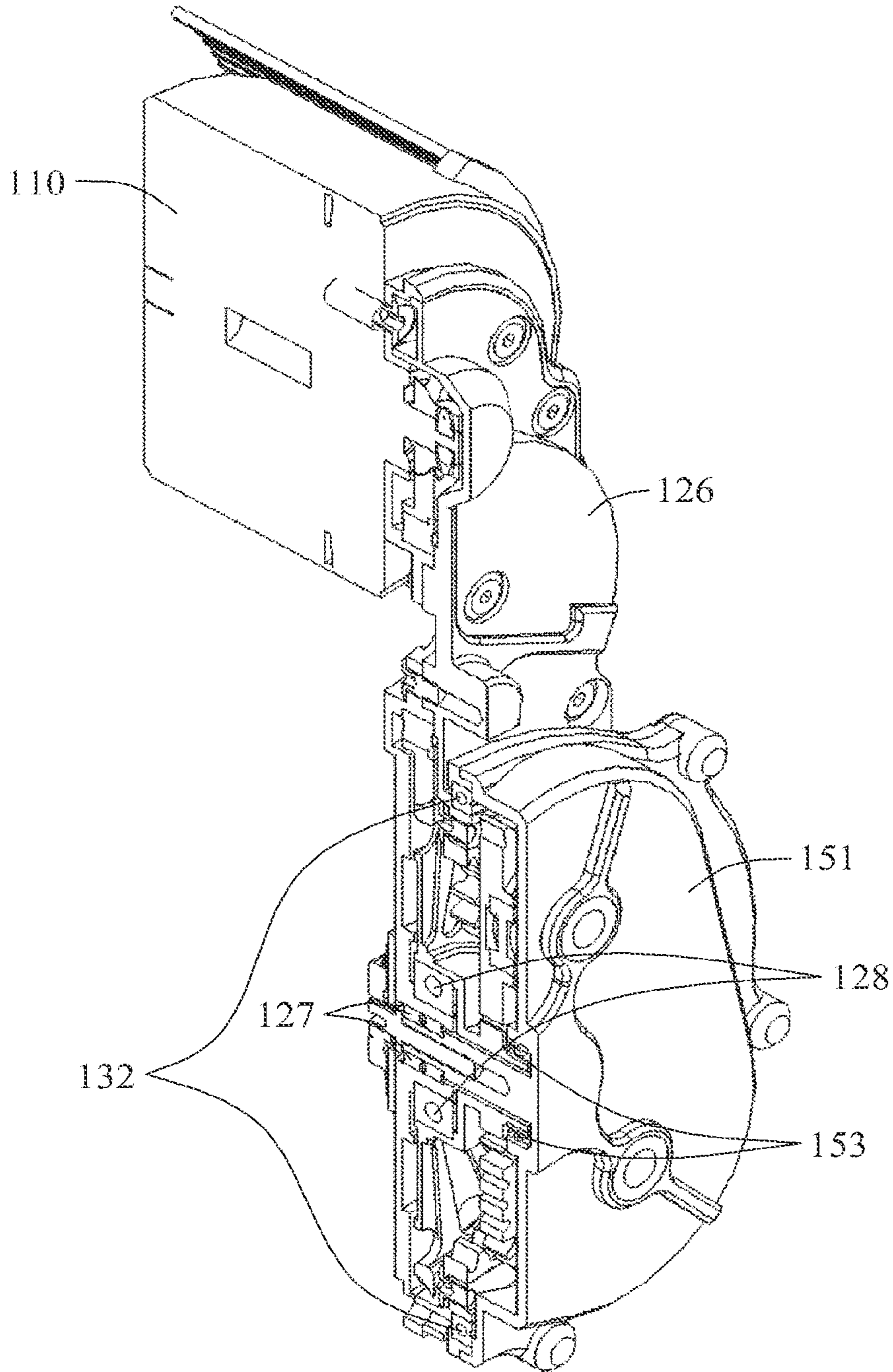


FIG. 11

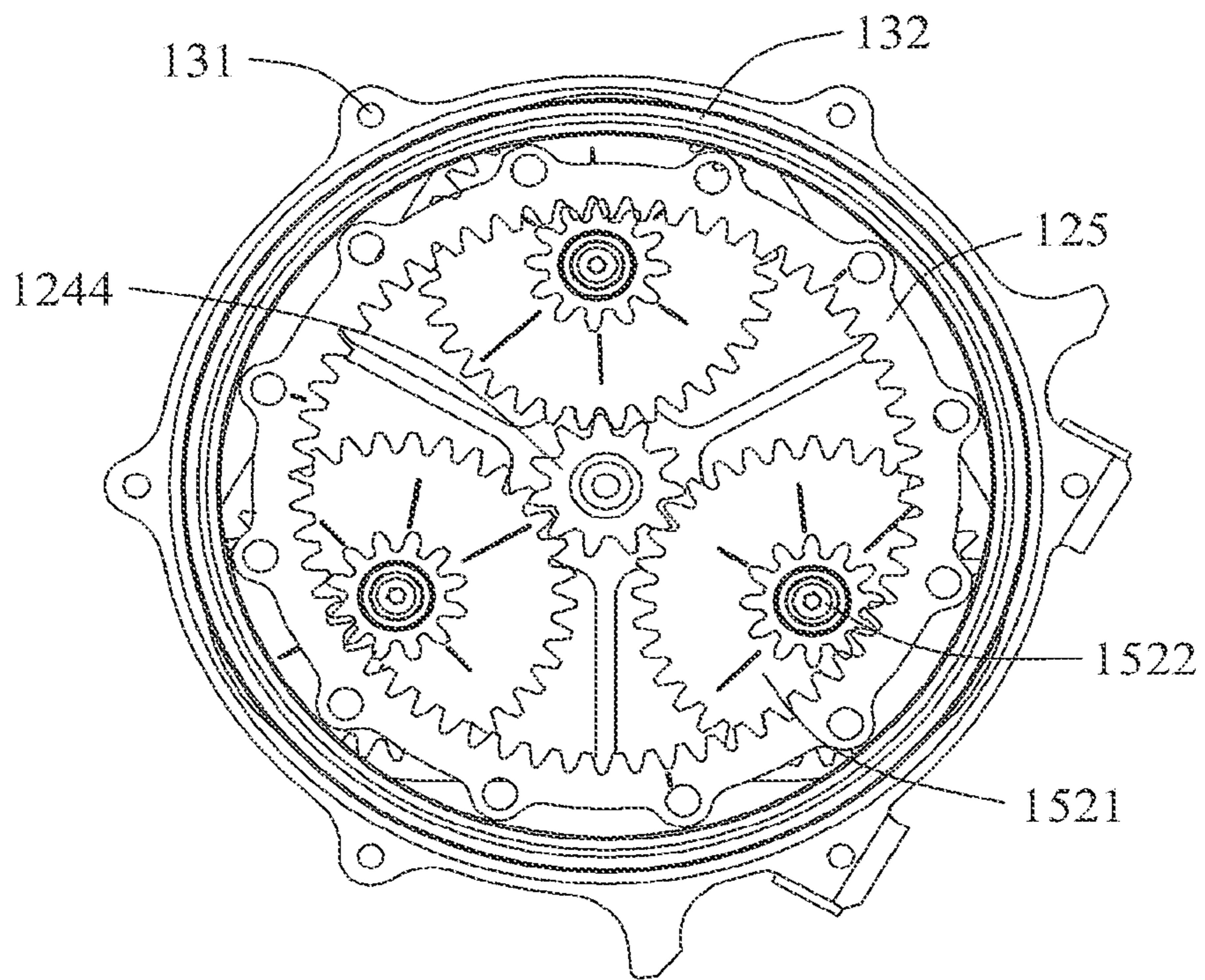


FIG. 12A

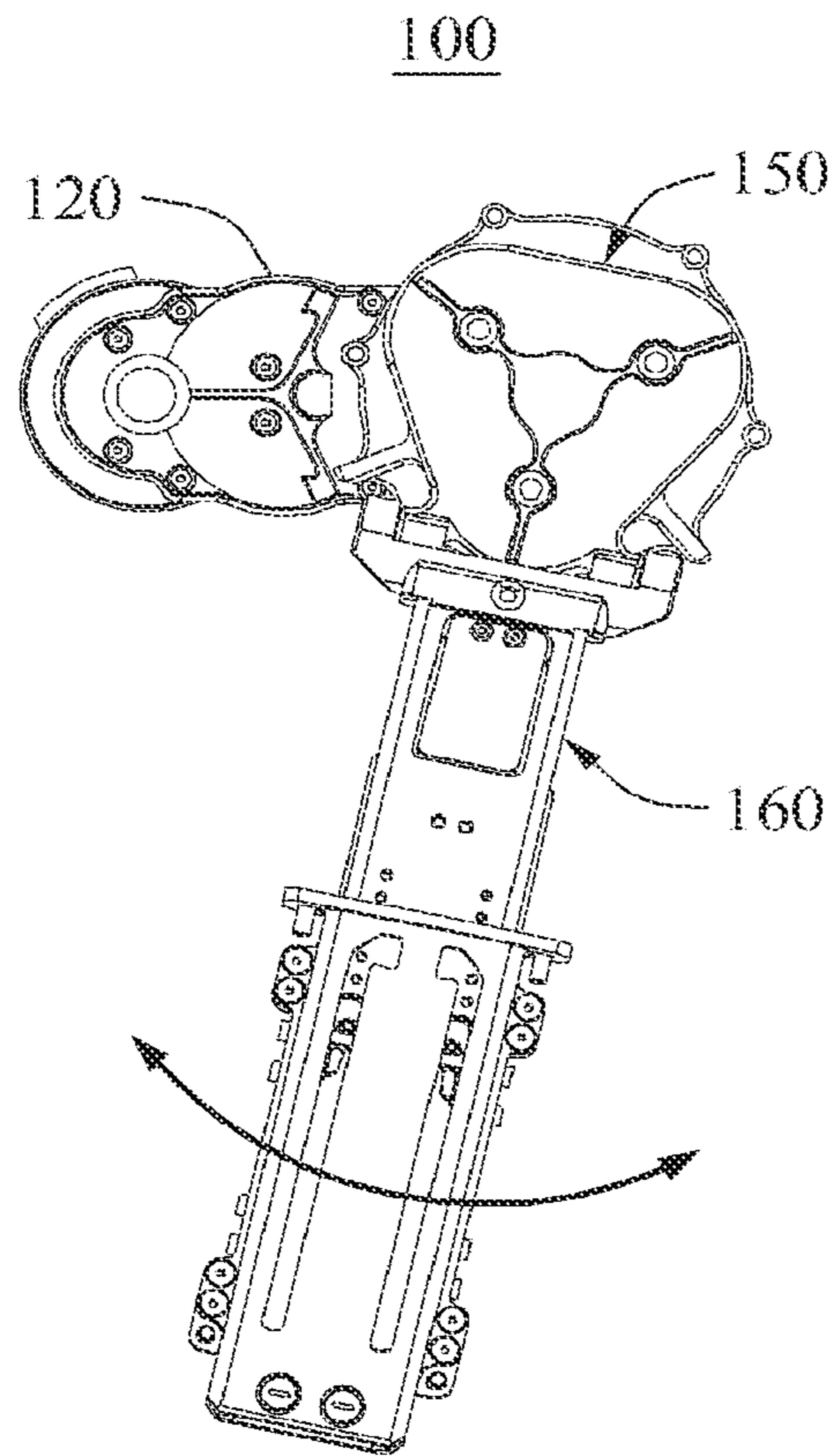
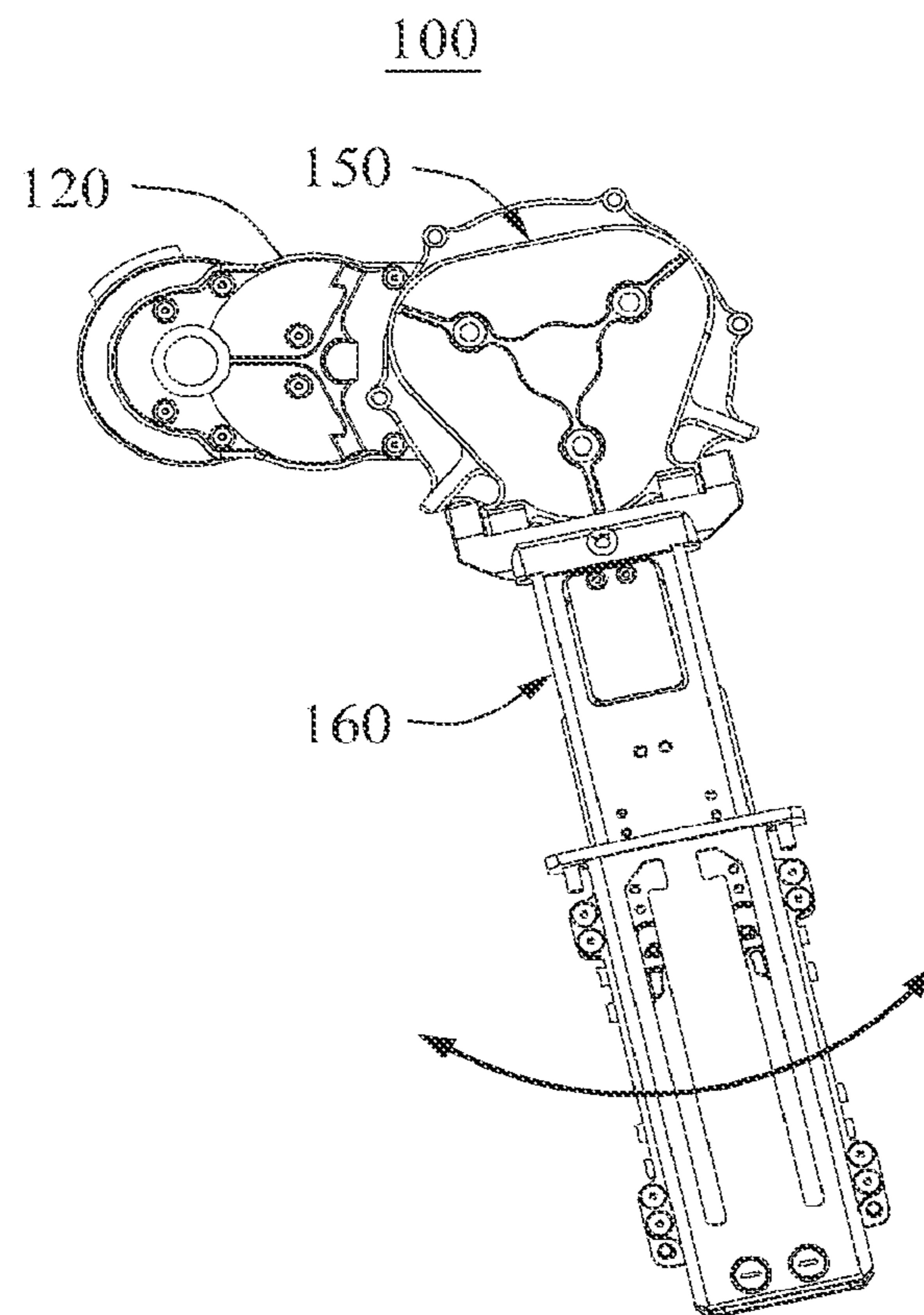


FIG. 12B



**DRIVING MODULE AND MOTION
ASSISTANCE APPARATUS INCLUDING THE
SAME**

CROSS-REFERENCE TO RELATED
APPLICATION

This application is a Continuation of U.S. application Ser. No. 17/180,281, filed Feb. 19, 2021, which is a Continuation of U.S. application Ser. No. 16/410,247, filed May 13, 2019 (now U.S. Pat. No. 10,952,917), which is a Divisional of U.S. application Ser. No. 16/263,531, filed Jan. 31, 2019 (now U.S. Pat. No. 10,952,915), which is a Divisional of U.S. application Ser. No. 14/796,583, filed Jul. 10, 2015 (now U.S. Pat. No. 10,231,894), all which claim priority to KR 10-2015-0002072, filed Jan. 7, 2015, the entire contents of which are all hereby incorporated herein by reference in their entireties.

BACKGROUND

1. Field

Example embodiments relate to a driving module and/or a motion assistance apparatus including the same.

2. Description of the Related Art

Biped walking may aid a human in performing various daily activities by freeing the hands of the human during walking. When experiencing difficulties in such significant walking, a human body may be exposed to a number of issues. For example, a decrease in muscular strength may restrict physical activities and cause a reduction in muscle mass, energy consumption, and metabolism.

Walking assistance robots/walking assistance devices are being developed to aid those people having difficulties in walking to be able to walk with less difficulty. Such robots/devices may be worn on/attached to a lower body of a user to intensify muscular strength and alleviate a burden by weight during walking or standing on a level ground, a slope, or stairs.

In general, the robots/devices may have a structure to assist motions of joints of a lower body, for example, hip joints, knee joints, and ankle joints using an actuator. In the past, such robots/devices were developed to assist walking/intensify muscular strength of a patient. However, recently, the robots/devices are being developed to improve walking abilities for military purposes, manufacturing purposes, and general walking assistance purposes.

For example, to transmit a force and a torque generated by the actuator to joints of a user, a wearable portion acting as an interface between joints of the user and the device may be provided to be attached to or to enclose a body of the user. When driving power is transmitted in a direction in which a joint portion of the device connected to the wearable portion matches a moving direction of the joint of the user, the force and the torque may be applied appropriately without causing inconvenience. A driving source may include a motor and a decelerator, and may be disposed at a position corresponding to an axis of rotation of the joint of the user. The wearable portion may be provided in a form of a belt or a band so that a frame connected to the driving source may be attached to a leg portion of the user. Such a structure may be an external skeleton structure in which the driving source and the

wearable portion are relatively thick, and may be worn over clothing to be exposed to an outside.

SUMMARY

Some example embodiments relate to a driving module.

In some example embodiments, the driving module may include a driving source configured to generate power, a gear train including a decelerating gear set configured to rotate using power received from the driving source, a joint aligning ring rotatably inserted into one side of the gear train, a rotary joint attached to the joint aligning ring, and configured to rotate using power received from the gear train, and a joint bearing disposed between the joint aligning ring and the rotary joint, and attached to the gear train.

The gear train may further include a first frame and a second frame configured to cover the decelerating gear set, and axes of rotation of gears included in the decelerating gear set may be formed as an integral body on at least one of the first frame and the second frame.

The decelerating gear set may include a base gear configured to act as an output end of the decelerating gear set, and at least one spur gear engaged between the driving source and the base gear.

One of the first frame and the second frame may include a cover portion configured to cover the at least one spur gear, and an edge portion connected to the cover portion, and on an outside of which the joint aligning ring is disposed.

The gear train may further include a ring gear attached to an inner side of the edge portion. The rotary joint may include at least one planetary gear engaged with the ring gear, and an axis of rotation of the planetary gear, and the axis of rotation of the planetary gear may be formed as an integral body on the rotary joint.

The base gear may include two gears having different diameters, and a small-diameter gear between the two gears of the base gear may be engaged with the planetary gear.

The planetary gear may include two gears having different diameters, and a large-diameter gear between the two gears of the planetary gear may be engaged with the small-diameter gear between the two gears of the base gear.

The gear train may further include a receiving protrusion including a groove configured to receive an axis of rotation of the rotary joint, a first bearing disposed between an inner wall of the groove and the axis of rotation of the rotary joint, and a second bearing disposed between an outer side of the receiving protrusion and an inner side of the base gear.

The rotary joint may include a rotation axis groove formed along a circumference of an axis of rotation of the rotary joint, and a third bearing disposed between a cylindrical end portion protruding from the base gear and an inner wall of the rotation axis groove.

The decelerating gear set may include an input gear connected to a shaft of the driving source, an idle gear engaged with the input gear, and a base gear engaged with the idle gear. Diameters of the input gear, the idle gear, and the base gear may increase sequentially in an order of power transmission.

The joint bearing may be configured to support at least one of an inner side of a contour of the joint aligning ring and an inner side of a contour of the rotary joint.

Other example embodiments relate to a driving module.

In some example embodiments, the driving module may include a driving source configured to generate power, a gear train including a decelerating gear set configured to receive driving power from the driving source, and a ring gear attached to one side thereof, and a rotary joint including at

3

least one planetary gear configured to rotate using power received from an output end of the decelerating gear set, and to revolve along the ring gear.

An axis of rotation of the at least one planetary gear may be formed as an integral body on the rotary joint.

The decelerating gear set may include a base gear configured to act as the output end. The base gear may include two gears having different diameters, and a small-diameter gear between the two gears may be engaged with the planetary gear.

The gear train may include a joint aligning ring fastened to the rotary joint, and the driving module may further include a joint bearing attached to one side of the gear train, and configured to prevent a separation of the joint aligning ring from the gear train.

The joint bearing may be a thin section bearing configured to reduce a torsion of the rotary joint.

Other example embodiments relate to a motion assistance apparatus.

In some example embodiments, the motion assistance apparatus may include a fixing module configured to be attached to a user, a driving module including a driving source disposed on one side of the fixing module, a gear train configured to receive driving power from the driving source, and a rotary joint including at least one planetary gear connected to an output end of the gear train, and a supporting module configured to support a portion of a body of the user, and to be driven by the driving module.

An axis of rotation of the at least one planetary gear may be formed as an integral body on an inner side of the rotary joint.

The driving source may be attached to the gear train, and the rotary joint may be configured to relatively rotate with respect to the gear train using the driving power.

The driving source may be detachable from the gear train, and the gear train may be detachable from the rotary joint.

Additional aspects of example embodiments will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

These and/or other aspects will become apparent and more readily appreciated from the following description of example embodiments, taken in conjunction with the accompanying drawings of which:

FIG. 1 is a side view of a motion assistance apparatus according to example embodiments;

FIG. 2 is a perspective view of a driving module according to example embodiments;

FIG. 3 is an exploded perspective view of a driving module according to example embodiments;

FIG. 4 is an exploded perspective view of the driving module of FIG. 3, viewed from another angle;

FIG. 5 is an exploded perspective view of a driving module according to example embodiments;

FIG. 6 is an exploded perspective view of the driving module of FIG. 5, viewed from another angle;

FIG. 7 is a partial exploded view of a driving module according to example embodiments;

FIG. 8 is a cross-sectional perspective view of the driving module of FIG. 7;

FIG. 9 is a cross-sectional view of a driving module according to example embodiments;

FIG. 10 is a cross-sectional perspective view of a driving module according to example embodiments;

4

FIG. 11 is a view illustrating an operation of a planetary gear according to example embodiments; and

FIGS. 12A and 12B are views illustrating an operation of a rotary joint according to example embodiments.

DETAILED DESCRIPTION

Hereinafter, some example embodiments will be described in detail with reference to the accompanying drawings. Regarding the reference numerals assigned to the elements in the drawings, it should be noted that like elements will be designated by like reference numerals, wherever possible, even though they are shown in different drawings. Also, in the description of the example embodiments, detailed description of well-known related structures or functions will be omitted.

It should be understood, however, that there is no intent to limit this disclosure to the particular example embodiments disclosed. On the contrary, the example embodiments are to cover all modifications, equivalents, and alternatives falling within the scope of example embodiments.

In addition, terms such as first, second, A, B, (a), (b), and the like may be used herein to describe components. Each of these terminologies is not used to define an essence, order or sequence of a corresponding component but is used merely to distinguish the corresponding component from other component(s). It should be noted that if it is described in the specification that one component is “connected”, “coupled”, or “joined” to another component, a third component may be “connected”, “coupled”, and “joined” between the first and second components, although the first component may be directly connected, coupled or joined to the second component.

The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms “a,” “an,” and “the,” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises,” “comprising,” “includes,” and/or “including,” when used herein, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

It should also be noted that in some alternative implementations, the functions/acts noted may occur out of the order noted in the figures. For example, two figures shown in succession may in fact be executed substantially concurrently or may sometimes be executed in the reverse order, depending upon the functionality/acts involved.

Various example embodiments will now be described more fully with reference to the accompanying drawings in which some example embodiments are shown. In the drawings, the thicknesses of layers and regions are exaggerated for clarity.

FIG. 1 is a side view of a motion assistance apparatus 1 according to example embodiments, and FIG. 2 is a perspective view of a driving module 100 according to example embodiments.

Referring to FIG. 1, the motion assistance apparatus 1 may be worn by a user to assist a motion of the user.

The user may be, for example, a human, an animal, or a robot. However, example embodiments are not limited thereto. Although FIG. 1 illustrates a case in which the motion assistance apparatus 1 assists a motion of a thigh of the user, the motion assistance apparatus 1 may assist a

5

motion of another part of an upper body, for example, a hand, an upper arm, and a lower arm of the user, or a motion of another part of a lower body, for example, a foot, and a calf of the user. Thus, the motion assistance apparatus **1** may assist a motion of a part of the user.

The motion assistance apparatus **1** may include a fixing module **30**, a supporting module **40**, the driving module **100**, and a controller **20** configured to control the driving module **100**.

The driving module **100** may include a driving source **110** disposed on one side of the fixing module **30**, a gear train **120** configured to receive driving power from the driving source **110**, and a rotary joint **150** including at least one planetary gear connected to an output end of the gear train **120**. A connecting member **160** may be connected to the rotary joint **150**. An insertion member **140** to be inserted into a supporting frame **46** may be connected to the connecting member **160**.

The driving module **100** may be disposed on a hip joint to drive a joint portion of the motion assistance apparatus **1**. Two driving modules **100** may be disposed on left and right hip joints to assist rotary motions of the left and right hip joints, respectively.

The driving module **100** will be described in detail later.

The fixing module **30** may be attached to the user. The fixing module **30** may be in contact with at least a portion of an outer surface of the user, and may be provided to cover the outer surface of the user. The fixing module **30** may include a curved surface to be in contact with the user. For example, the fixing module **30** may be attached to one or more sides of a waist of the user.

The supporting module **40** may include the supporting frame **46**. The supporting frame **46** coupled to the connecting member **160** may rotate in a direction in which the connecting member **160** is rotated by the driving module **100**. The supporting module **40** may further include a pressurizing member **48** connected from the supporting frame **46**, and a supporting member **49**.

The pressurizing member **48** may be connected to one or more sides of the supporting frame **46**. For example, the pressurizing member **48** may be disposed on one side of a leg of the user to pull or push a thigh of the user. The pressurizing member **48** may be disposed on a front surface of the thigh of the user.

The supporting member **49** may be connected to one side of the pressurizing member **48**. For example, the supporting member **49** may be disposed to cover a circumference of at least a portion of the thigh of the user, thereby preventing a separation of the thigh of the user from the supporting frame **44**. The supporting member **49** may be disposed on an opposite side of the pressurizing member **48** from the thigh of the user.

A torque generated by the driving module **100** may be transmitted to the supporting module **40** through the connecting member **160**. The torque transmitted through the supporting module **40** may be used to lift the thigh of the user through the pressurizing member **48**, thereby assisting a motion of the user.

The controller **20** may include a processor and a memory (not shown).

The memory may be any device capable of storing data including magnetic storage, flash storage, etc. The processor may be any device capable of processing data including, for example, a microprocessor configured to carry out specific operations by performing arithmetical, logical, and input/output operations based on input data, or capable of executing instructions included in computer readable code stored

6

in the memory. The processor may be a logic chip, for example, a central processing unit (CPU), a controller, or an application-specific integrated circuit (ASIC), that when, executing the instructions stored in the memory, configures the processor as a special purpose machine to control the driving module **100**.

FIG. **3** is an exploded perspective view of the driving module **100** according to example embodiments, and FIG. **4** is an exploded perspective view of the driving module **100** of FIG. **3**, viewed from another angle. In detail, FIG. **3** illustrates the driving module **100** viewed from the rotary joint **150**, and FIG. **4** illustrates the driving module **100** viewed from the driving source **110**.

FIG. **5** is an exploded perspective view of the driving module **100** according to example embodiments, and FIG. **6** is an exploded perspective view of the driving module **100** of FIG. **5**, viewed from another angle. In detail, FIG. **5** illustrates the driving module **100** viewed from the rotary joint **150**, and FIG. **6** illustrates the driving module **100** viewed from the driving source **110**.

Referring to FIGS. **3** to **6**, the driving module **100** may include the driving source **110** configured to generate power, the gear train **120** configured to receive driving power from the driving source **110**, a joint aligning ring **131** rotatably inserted into one side of the gear train **120**, the rotary joint **150** attached to the joint aligning ring **131** and configured to rotate using power received from the gear train **120**, and a joint bearing **132** disposed between the joint aligning ring **131** and the rotary joint **150** and attached to the gear train **120**.

The driving source **110** may generate power to be used to drive the rotary joint **150**. The driving source **110** may be disposed, for example, in a space between a thigh and a hip of the user. The driving source **110** may be, for example, an electric motor. However, the type of the driving source **110** is not limited thereto.

The gear train **120** may be driven using power received from the driving source **110**. The gear train **120** may include a decelerating gear set including gears **122**, **123**, and **124**, a ring gear **125** attached to one side thereof, and a first frame **121** and a second frame **126** configured to cover the decelerating gear set.

The decelerating gear set may decrease a rotation velocity of a rotary motion transmitted from the driving module **100** and generate a relatively great torque. The decelerating gear set may include, for example, spur gears or helical gears. A gear acting as an output end of the decelerating gear set may be referred to as the base gear **124**. The base gear **124** may include two gears having different diameters. A small-diameter gear between the two gears of the base gear **125** may act as a sun gear to be engaged with a planetary gear **152**.

Axes of rotation of the plurality of gears **122**, **123**, and **124** in the decelerating gear set may be formed as an integral body on the first frame **121**. By providing the axes of rotation of the gears **122**, **123**, and **124** constituting the decelerating gear set as an integral body on the first frame **121**, additional components and spaces to be used to fix the axes of rotation of the gears **122**, **123**, and **124** to the first frame **121** may be unnecessary. Thus, a size of the gear train **120** may be minimized.

The first frame **121** may be provided in a shape of a thin plate in which a small-sized circle, a medium-sized circle overlapping a portion of the small-sized circle, and a large-sized circle overlapping a portion of the medium-sized circle are arranged sequentially, based on a shape of the decelerating gear set.

The driving source **110** may be connected to one surface of the first frame **121**, and the second frame **126** having substantially the same contour as the first frame **121** may be connected to an opposite surface of the first frame **121**. Bolt holes may be provided along the contours of the first frame **121** and the second frame **126** to couple the first frame **121** and the second frame **126**.

The second frame **126** may include a cover portion **1261** configured to cover at least one gear in the decelerating gear set, and an edge portion **1262** connected to the cover portion **1261** and on an outside of which the joint aligning ring **131** is disposed. The cover portion **1261** and the edge portion **1262** may be formed as an integrated single frame.

The ring gear **125** may be attached to an inner side of the edge portion **1262**. The edge portion **1262** may be disposed along a circumference of a hollow having a size that may expose teeth of the ring gear **125** protruding toward a center of the circumference. The planetary gear **152** may penetrate through the hollow and be engaged with the ring gear **125**.

The joint bearing **132** may be disposed on an outer side of the edge portion **1262**. The joint bearing **132** may have a large diameter sufficient to firmly support a rotary cover **151** of the rotary joint **150**. The joint bearing **132** may be attached to the second frame **126** to prevent a separation of the joint aligning ring **131**. The joint bearing **132** may support at least one of an inner side of a contour of the joint aligning ring **131** and an inner side of a contour of the rotary joint **150**. A thin section bearing may be used as the joint bearing **132**.

The joint aligning ring **131** to be attached to the rotary joint **150** may be disposed between the second frame **126** and the joint bearing **132**. The joint aligning ring **131** may rotate between the second frame **126** and the joint bearing **132**. The joint aligning ring **131** may be inserted into a portion protruding from the second frame **126** toward the rotary joint **150**. For example, a portion protruding toward a circumference of the joint aligning ring **131** and a portion protruding toward an outer side of the rotary cover **151** may be coupled using an adhesive or bolts.

The rotary joint **150** may rotate using power received from the output end of the gear train **120**. The rotary joint **150** may be rotatably connected to the gear train **120** using the joint aligning ring **131**. A shape of the contour of the rotary joint **150** may have a size corresponding to the large-sized circle of the first frame **121**. The rotary joint **150** may be modularized to be detachable from the gear train **120**. The rotary joint **150** may include the rotary cover **151** configured to cover the hollow of the edge portion **1262**, the at least one planetary gear **152**, and a third bearing **153**.

The rotary cover **151** may be a shaft-integrated frame in which an axis of rotation of the at least one planetary gear **152** is configured as an integral body. The rotary cover **151** may include a joint connection link configured to rotatably connect the connecting member **160** to the rotary joint **150**.

The axis of rotation of the at least one planetary gear **152** may be formed as an integral body with the rotary cover **151**, similar to the first frame **121** of the gear train **120**.

Hereinafter, descriptions will be provided based on an order of power transmission.

A torque generated by the driving source **110** of the gear train **120** may be transmitted to the input gear **122**, also referred to as a driving gear, of the decelerating gear set, and transmitted to the planetary gear **152** through the idle gear **123** and the base gear **124**.

The input gear **122** may be connected directly to an axis of rotation of the driving source **110**, or connected to the axis of rotation of the driving source **110** through coupling. The

idle gear **123** may be engaged with the input gear **122**, and the base gear **124** may be engaged with the idle gear **123**. Diameters of the input gear **122**, the idle gear **123**, and the base gear **124** may increase sequentially in the order of power transmission. The base gear **124** may act as an output end of the decelerating gear set.

The base gear **124** may include two gears **1241** and **1244** having different diameters, including a large-diameter gear **1241** and a small-diameter gear **1244**. The small-diameter gear **1244** of the base gear **124** may be engaged with the planetary gear **152**. The small-diameter gear **1244** may also be referred to as a sun gear. The large-diameter gear **1241** of the base gear **124** may be engaged with the idle gear **123**.

A Cylinder **1242** is located between the large-diameter gear **1241** and a small-diameter gear **1244**. The small-diameter gear **1244** is moved from the large-diameter gear **1241** to the central axis of the base gear **124** to broaden the gap between them. The height of The Cylinder **1242** is selected up to the point which the small-diameter gear **1244** and the planetary gear **152** are engaged. A diameter of The Cylinder **1242** is smaller than the diameter of large-diameter gear **1241** and larger than the diameter of a small-diameter gear **1244**.

The base gear **124** may be a compound gear. The base gear **124** may be an integrated gear sharing a common axis with the small-diameter gear **1244** protruding from the large-diameter gear **1241**. The small-diameter gear **1244** may act as a sun gear in a relationship with the planetary gear **152**.

A final torque generated by the driving source **110** and to be transmitted to an output end may be transmitted to the small-diameter gear **1244** protruding from the base gear **124**.

The torque transmitted to the small-diameter gear **1244** may be transmitted to three planetary gears **152**. When the planetary gears **152** rotate along an inner circumference of the ring gear **125** attached to the second frame **126**, the planetary gears **152** may simultaneously rotate while being engaged with the ring gear **125** and revolve on an axis of rotation **1511** of the rotary joint **150**.

Axes of rotation of the planetary gears **152** may be fixed, and the rotary cover **151** of the rotary joint **150** may rotate on the axis of rotation **1511** of the rotary joint **150**. Thus, the entire rotary joint **150** may rotate in a forward or backward direction.

The gear train **120** may include a receiving protrusion **129** including a groove **130** configured to receive the axis of rotation **1511** of the rotary joint **150**, a first bearing **127** disposed between an inner wall of the groove **130** and the axis of rotation **1511** of the rotary joint **150**, and a second bearing **128** disposed between an outer side of the receiving protrusion **129** and an inner side of the base gear **124**.

The rotary joint **150** may include the rotary cover **151**, a rotation axis groove **1512** formed on a circumference of the axis of rotation **1511** of the rotary cover **151**, and the third bearing **153** disposed between a cylindrical end portion **1243** protruding from the base gear **124** and an inner wall of the rotation axis groove **1512**. Axes of rotation **1513** of the at least one planetary gear **152** may be formed as an integral body on the rotary cover **151**.

FIG. 7 is a partial exploded view of the driving module **100** according to example embodiments, and FIG. 8 is a cross-sectional perspective view of the driving module **100** of FIG. 7. FIG. 9 is a cross-sectional view of the driving module **100** according to example embodiments, and FIG. 10 is a cross-sectional perspective view of the driving module **100** according to example embodiments.

Referring to FIGS. 7 through 10, the first frame 121 may include the receiving protrusion 129 including the groove 130 configured to receive the axis of rotation 1511 of the rotary joint 150. The first bearing 127 may be provided between an inner wall of the groove 130 and an outer wall of the axis of rotation 1511 of the rotary joint 150.

The second bearing 128 may be provided between the base gear 124 and the first frame 121 to assist a rotation of the base gear 124.

The rotation axis groove 1512 may be formed on a circumference of the axis of rotation 1511 of the rotary cover 151, and the third bearing 153 may be provided between an outer wall of the cylindrical end portion 1243 protruding from the base gear 124 and an inner wall of the rotation axis groove 1512.

The rotary joint 150 including the rotary cover 151 provided in a form of a shaft-integrated frame may be supported by the joint bearing 132. A thin section bearing having an extremely large diameter may be used for the joint bearing 132. In this example, a stiffness with respect to a torsion of the rotary cover 151 may increase.

Both ends of the base gear 124 disposed at a center of the gear train 120 may be supported by the rotary cover 151 and the first frame 121. In detail, one end of the base gear 124 may be supported by the third bearing 153 and an axis of rotation of the rotary cover 151 in a form of a shaft-integrated frame constituting the rotary joint 150. The other end of the base gear 124 may be supported by the first bearing 127 and the first frame 121 in a form of a shaft-integrated frame of the gear train 120.

FIG. 11 is a view illustrating an operation of the planetary gear 152 according to example embodiments.

Structures of the base gear 124, the ring gear 125, and the planetary gear 152 will be described in detail with reference to FIG. 11.

The planetary gear 152 may include a large-diameter gear 1521 and a small-diameter gear 1522, and the large-diameter gear 1521 may be engaged with the small-diameter gear 1244 of the base gear 124. The small-diameter gear 1522 may be engaged with the ring gear 125.

By a torque generated by the driving source 110, the small-diameter gear 1244 of the base gear 124 may be engaged with the small-diameter gear 1522 of the planetary gear 152 to generate a rotation, and the ring gear 125 may be engaged with the large-diameter gear 1521 of the planetary gear 152 to restrict a rotation.

Thus, the plurality of planetary gears 152 may revolve along a circumference formed by the plurality of planetary gears 152. Since the axes of rotation of the planetary gears 152 may be integrated on the rotary cover 151, the rotary cover 151 may rotate on a center of the circumference formed by the plurality of planetary gears 152.

FIGS. 12A and 12B are views illustrating an operation of the rotary joint 150 according to example embodiments.

Referring to FIGS. 12A and 12B, the driving source 110 may be attached to the gear train 120, and the rotary joint 150 may relatively rotate with respect to the gear train 120

using driving power. Based on a rotation direction of the rotary joint 150, the connecting member 160 connected to the rotary joint 150 may rotate in a forward or backward direction.

In the modularized structure, the driving source 110 may be detachable from the gear train 120, and the gear train 120 may be detachable from the rotary joint 150.

A number of example embodiments have been described above. Nevertheless, it should be understood that various modifications may be made to these example embodiments. For example, suitable results may be achieved if the described techniques are performed in a different order and/or if components in a described system, architecture, device, or circuit are combined in a different manner and/or replaced or supplemented by other components or their equivalents. Accordingly, other implementations are within the scope of the following claims.

What is claimed is:

1. A motion assistance apparatus comprising:

a fixing module, comprising a support, configured to attach to a waist of a user;

a driving module including:

a driving source, comprising a motor, on a side of the fixing module,

a gear train including an input gear connectable to the driving source, an idle gear engaged with the input gear, and a base gear engaged with the idle gear, wherein the input gear, the idle gear, and the base gear are arranged side by side in a direction crossing an axis of rotation of the input gear, and

a rotary joint including at least one planetary gear engageable with the base gear so that the base gear can act as a sun gear to the at least one planetary gear, and so that the rotary joint is thereby rotatable via driving power provided by the driving source; and

a supporting module, comprising a support, configured to cover at least part of a thigh of the user, and which is movable by rotation of the rotary joint via the driving power provided by the driving source.

2. The motion assistance apparatus of claim 1, wherein the at least one planetary gear is configured to rotate about an axis of rotation of the at least one planetary gear, the axis of rotation of the at least one planetary gear being an integral body on an inner side of the rotary joint.

3. The motion assistance apparatus of claim 1, wherein the driving source is configured to attach to the gear train, and

the rotary joint is configured to relatively rotate with respect to the gear train using the driving power.

4. The motion assistance apparatus of claim 1, wherein the driving source is configured to detach from the gear train, and

the gear train is configured to detach from the rotary joint.

* * * * *